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ABSTRACT

Three conference papers on rehabilitation technology, authored by staff members of the Trace Research and Development Center, form this collection. The first, "Keyboard Equivalent for Mouse Input" by Charles Lee and Gregg Vanderheiden, describes implementation of a keyboard mouse input device using the numeric keypad. The paper discusses experimentation with such features as smooth point motion, single pixel motion, and adjustable speed and acceleration of the pointer. The second paper, "Using the Occupational Therapy Comprehensive Functional Assessment (OTCFA) To Evaluate the Efficacy of Technological Intervention in Rehabilitation" by Roger Smith, reviews the historical development of rehabilitation assessments. It describes the introduction of a tool to integrate various aspects of functional assessment and provide a standard, comprehensive method for assessing the overall performance of an individual, including the technological equipment and environmental factors contributing to performance. The final paper, "Features To Increase the Accessibility of Computers by Persons with Disabilities: Report from the Industry/Government Task Force" by Gregg Vanderheiden, Charles Lee, and Lawrence Scadden, discusses the Task Force's efforts to identify difficulties faced by disabled persons in the use of standard computers, possible approaches for reducing the difficulties, and current microcomputer features which facilitate use by disabled persons. (JDD)

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TRACE AUTHORED PAPERS FROM THE TENTH ANNUAL CONFERENCE ON REHABILITATION TECHNOLOGY - 1987

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Table of Contents

Page

Keyboard Equivalent for Mouse Input 1

Using the Occupational Therapy Comprehensive Functional Assessment (OTCFA) to Evaluate the Efficacy of Technological Intervention in Rehabilitation 4

Features to Increase the Accessibility of Computers by Persons With Disabilities: Report From the Industry/ Government Task Force 10

KEYBOARD EQUIVALENT FOR MOUSE INPUT

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ABSTRACT

Operation of a computer and application software is becoming dependent on the ability to use a mouse. This makes it impossible for many disabled individuals to use these computers. A possible solution is to provide a keyboard equivalent for mouse input. This is a reasonable approach since there are already many ways for the disabled individual to use a keyboard or emulate keyboard input. However, it is not enough nor always easy to accomplish the technical aspects of this task. Human factors engineering approaches must be used to make the keyboard emulation of the mouse as intuitive and as easy to use as possible, and future operating systems need to be designed to make implementation of this solution feasible.

INTRODUCTION

There is clear distinction between the purpose of the physical mouse on the table top and the purpose of the pointer on the screen. The mouse is a device used by the operating system to move a pointer on the screen and to provide certain events (button down/up, clicks) as input to programs. Programs are interested in the position and motion of the pointer when other actions occur, and not the exact position or motion of the mouse.

This distinction is very important since we are trying to emulate the types of information a program expects from the use of a mouse, and not the physical mouse. If we try to emulate the physical mouse, we are two steps removed from what the program wants.

RESULTS

We found that implementation of a keyboard mouse (Mouse Keys) should use the numeric keypad for two reasons:

1) it allows other keys (including cursor keys) to remain active while using Mouse Keys,
2) and it provides intuitive directional key layout.

We also discovered that there should be the following features:

1) smooth motion of the pointer,
2) single pixel motion by tapping the keys,
3) slow constant acceleration of the pointer up to a maximum speed when the keys are held down,
4) adjustable maximum speed and acceleration,
5) lower maximum speeds for individuals with slower key release times,
6) single click and button down and up functions.

We also discovered the following:

1) the velocity in the diagonal directions does not have to be the same as in the orthogonal directions but can be made up of the vertical and horizontal components,
2) it is useful to have hyper screen and window motion modes,
3) it is useful to have double, and triple click functions,
4) and it is useful to have an adjustable initial step.

DISCUSSION

Goals of a good design

The goals of a good design are 1) to provide the same information that the mouse provides to the programs, namely pointer position and motion, and button events and 2) to provide a good human-machine interface.

Which keys to use

The two consideration in determining which keys to use are 1) which keys provide the most intuitive interface to moving the pointer around the screen and 2) which keys are duplicated by others so that with Mouse Keys enabled, the user can still operate the software.

The numeric keypad is a very good choice since the key layout provides an intuitive set of keys for moving the pointer in eight direction, and most of the numeric keypad keys are duplicated by other keys on the keyboard.

Enabling mouse keys

The method for enabling Mouse Keys needs to satisfy the following guidelines:

1) no other program should expect the same sequence of keystrokes,
2) and getting out must be logically related to getting in.

For instance, on an IBM PC, if an "alt-m" (alt-mouse) enables Mouse Keys then "alt-k" (alt-keyboard) should disable Mouse Keys. If "ctl-alt-numlock" is used for enabling then just a "numlock" or another "ctl-alt-numlock" should be used for disabling. On a Macintosh, a command-shift-clear might be used. The danger of using the exact same key combination to enable and disable is that it can get very confusing. It is then difficult to determine if Mouse Keys is enabled or disabled unless there is some indication of the state.

Smooth versus lumpy pointer motion

The pointer is meant to represent a physical object on the screen and physical objects move in a smooth and continuous fashion. Jumpy motion of the pointer is therefore undesirable since it makes the relation of the pointer to the desired motion less intuitive. The motion of the pointer using Mouse Keys should maintain this characteristic. A smooth moving pointer also gives immediate visual feedback as to the position, velocity and acceleration of the pointer so accurate prediction of its location upon release of the keys is easier to make.

The keyboard is a discrete event device, so the most natural way to implement pointer motion using the keyboard is to move the mouse every time there is a key, or a key-repeat. This would produce a smooth motion if the pointer moved only a few pixels per key. However, with this method it would take a long time to move across the screen for users with a slow key repeat rate.

A good way to get around this problem is to use the initial down stroke of the key to move the pointer one pixel (thus always giving very accurate control) and as soon as the key starts to autorepeat, the pointer should start moving in a smooth motion, first slowly and then faster until it reaches a maximum speed. As soon as the key is released, the cursor should stop. The reason it should start off slow and then get faster is due to the fact that the amount of time it takes a person to recognize the cursor is moving and then release

the finger is not instantaneous. If its motion starts at the maximum speed then it is very difficult to move the pointer a short distance.

Use of the auto repeat feature

The key repeat delay is the time after the press of a key before the auto repeat starts. It will be assumed that an individual adjusts (if possible) the Delay so that the he/she can consistently and easily press and release a key and get only only one character each time.

The key repeat interval is the time between the auto repeat of the keys. It is assumed that the repeat interval is adjusted so that the individual when trying to get a certain number of characters using the auto repeat will consistently get within one of the desired number. This means that they are able to position the cursor within three repeat interval values. We will assume that the consistency of accomplishing this is 99.7%. This means that 99.7% of the attempts will produce results that fall within three standard deviations (based upon the theory of normal distribution).

Determination of maximum speed of pointer motion

The maximum speed of the pointer is very dependent on the physical ability of the user. In determining the maximum rate of speed the key repeat rate must be taken into account. If the repeat interval is 0.1 seconds (i.e. 10 characters per second) and the pointer is moving at 100 pixels per second, then the user is able to accurately release the key within 0.3 seconds 99.7% of the time, thus placing the pointer within +/- 15 pixels. If an accuracy of +/- 5 pixels is desired, then the maximum speed must be set to 33 pixels per second.

This was confirmed by experimentation which is summarized in Table 1. Although there seem to be some inconsistencies with the theory, they can be explained as follows. Subject 2 showed poor correlation due to the fact that when setting the repeat interval, the next faster speed (4/60 sec) was not selected since it was just a little too fast. Subject 4 showed high positive average error due to the inability to predict the motion of the pointer. The subject would not attempt to release the key until after seeing the pointer at the target. Subject 5 showed poor correlation since the computer could not have the repeat interval set any slower than 12/60 second without going to an incredibly slow rate (144/60 second). Subject 7 showed poor correlation due to a problem with maintaining concentration in the task. The subject several times forgot to release the key because the subject's inattentiveness. This is shown in the high positive average error.

These results indicate that the ability to use Mouse Keys at the maximum speed depend not only on the consistency and speed of the physical release time of the key but also on the individual's reaction time and motion prediction ability.

In determining the desired placement accuracy, a small enough value should be chosen to meet the nominal required accuracy of the placement of the pointer by the system or application software, which tends to be between three and five pixels. Requiring that six standard deviations of consistency be used is based upon the fact that individuals get easily and quickly fatigued in using pointing devices if they constantly over- or under-shoot the desired location on the first attempt and have to try again. Therefore, accuracy of placement of the pointer on the first attempt should always prevail over the desire to move the pointer quickly over long distances.

Determination of pointer acceleration

There are two simple ways of implementing acceleration of the pointer: constant and linear acceleration.

We discovered that a constant acceleration approach works the best since it is the most familiar and thus induces less cognitive load. In the task of estimating the time of arrival of an accelerating object, people are most familiar with the motion of objects in the air. Objects moving in the air are subject to constant acceleration (gravity) and so we are very accustomed to estimating the arrival of an object (baseball) to a point (the mitt) when the object has constant acceleration. Constant acceleration also provides sufficient gradation of motion from initial to final velocity to provide accurate placement of the pointer to close distances.

We discovered that the critical factor in determining the acceleration was fairly independent of the individual's speed at using the keyboard. Most individuals preferred the time it took for the pointer to reach the maximum speed to be somewhere between 3 and 4 seconds. The limiting factor depends on how quickly and comfortably the mind can accurately predict an accelerating object's location.

Directional dependencies

Although there were some differences in the accuracy and standard deviation in the different directions for each user (see Table 2), there were no clear patterns nor any consistency (e.g. subject 5 was able to move to the right more accurately than to the left, but subjects 3 and 6 were not able). Therefore it does not seem appropriate to have an implementation of Mouse Keys allow for variation in maximum speed and acceleration depending on the direction of motion.

Uniform speed in all directions versus in orthogonal directions

At first it was thought that the pointer should move at the exact same speed in all directions even though from an implementation standpoint it is easier to maintain the same speed in just the orthogonal directions and let the diagonal directions be faster by 41% (square root of 2). However, we found that even though a uniform velocity tends to allow more accurate placement in the diagonal directions, the accuracy of placement with non-uniform speed in the diagonal directions was no worse than in the orthogonal directions (see Table 3). This is because the maximum speed is optimized for the orthogonal directions and the error is based on

Subject No.	Key Repeat Delay (1/60 sec)	Key Repeat Interval (1/60 sec)	Maximum Speed (pix/sec)	Average Error (pixels)	Standard Deviation	Predicted Standard Deviation	Error %	New Recalculated KeyRepThresh
1	16	2	180	0.41	2.86	3.00	-4.7	1.91
2	16	8	40	0.17	1.70	2.67	-36.3	5.10
3	24	12	30	0.48	2.81	3.00	-6.3	11.24
4	24	12	30	2.36	3.08	3.00	2.7	12.32
5	24	12	25	2.30	2.98	2.50	19.2	14.30
6	40	12	20	1.71	2.30	2.00	15.0	13.80
7	40	12	20	4.75	2.66	2.00	33.0	15.96

Table 1

Subject No.	Up		Down		Left		Right	
	Average Error (pixels)	Standard Deviation	Average Error (pixels)	Standard Deviation	Average Error (pixels)	Standard Deviation	Average Error (pixels)	Standard Deviation
1	0.51	2.13	1.45	2.43	0.43	2.17	0.34	3.02
3	1.00	2.90	*	*	-0.33	3.56	0.67	3.67
5	2.00	1.95	1.08	2.71	1.75	1.82	0.04	2.97
6	2.00	2.53	1.00	1.10	1.17	4.12	1.75	2.96

Table 2

pixels in the orthogonal directions rather than distance in the diagonal direction.

Optional initial step motions

It was assumed that all users are able to use the auto repeat feature. However, this might not always be the case. If the auto repeat feature is off, Mouse Keys should allow the initial step to be adjusted to values other than one. This way, the user who is not able to use the auto repeat (due to very slow release times and erratic release times) and has disabled it, can move quickly across the screen by setting the initial jump to five or ten pixels per key press. This feature also lets all users make accurate long movements without having to tap the key many times. For example, to move exactly 100 pixels to the right, normally one would tap the "6" key 100 times. But if the initial jump were set to 10, then one would need to tap the key only 10 times. The initial step could be set by first typing the "set key" and then one of the number keys with "0" being equal to 10.

Hyper modes

After use of Mouse Keys, it was found that two modes called screen-hyper and window-hyper function would be very helpful. The screen-hyper function allows the pointer to jump to the center, or near to the edges or corners of the screen. A simple way to provide this is to have a screen-hyper key which when pressed before a direction key, makes the pointer jump to the edge of the screen in the relative directions or to the middle of the screen if the "5" key on the numeric keypad was pressed. This would be very useful to quickly move around on the screen. If the computer system has menu bars at the top of the screen the screen-hyper function makes it very easy to get to the menu bar. The window-hyper function is identical to the screen-hyper function except that the pointer would jump relative to the current window under the pointer. Again, if there are significant areas near the edge of the window (e.g. title bar, close box, scroll bars, size box, zoom box, etc.) then this feature makes it very easy to quickly move to those locations.

Difficulties in implementation

The following list of features of an operating system that would greatly facilitate implementation of Mouse Keys is based on our experience trying to implement Mouse Keys on the IBM to work with Microsoft Word and Windows using Microsoft's serial mouse, and on the Macintosh computer:

1) There should be a well defined way to hook into keyboard events and to inhibit or pass them on. From this hook, it should be possible to have access to the full computer (i.e. the keyboard hook should not be at interrupt time). This hook should be early enough in the chain to be able to distinguish as many keys as possible and before the key is passed to the operating system and application program.
2) There should also be a way to hook into the real mouse input (again not at interrupt time) in order to "OR" button information with mouse key buttons or to inhibit real mouse information all together.
3) There should be a defined way to inject multiple mouse events (motion and button action) and to set the position to absolute or relative position on the screen.
4) The routines that draw the pointer should not occur at mouse interrupt time but after the translation of mouse motions into pointer positions.
5) There should also be a mechanism to get CPU time intermittently, preferably every vertical retrace of the screen, in order to create a smooth moving pointer.
6) The mouse and Mouse Key routines should be able to work from the same pointer position so that either of them can move the pointer at the same time or alternately.

Subject No.	Uniform		Non-Uniform	
	Average Error (pixels)	Standard Deviation	Average Error (pixels)	Standard Deviation
1	0.31	1.66	0.49	2.74
3	-0.50	2.26	0.56	1.81
5	0.50	2.72	0.17	2.24
6	-0.58	2.84	2.50	1.78

Table 3

CONCLUSION

Mouse and graphical based computer systems are praised for their ease of use and intuitiveness. These benefits should not be limited to only those that can use the physical mouse. The Mouse Key solution can be easily implemented on future computers with some fore thought in the design of the computer's operating system.

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USING THE OCCUPATIONAL THERAPY COMPREHENSIVE FUNCTIONAL ASSESSMENT (OTCFA) TO EVALUATE THE EFFICACY OF TECHNOLOGICAL INTERVENTION IN REHABILITATION

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ABSTRACT

Functional assessment in rehabilitation medicine and in rehabilitation technology has received vital research and development attention in the last few years. In the early 1980s, NIDRR supported the priority of quantitative assessment, and rehabilitation engineering centers and agencies have since produced assessment technologies (including Tufts REC, CP Research Foundation of Kansas, Assistive Device Center in California, Dallas Rehabilitation Foundation, MIT REC, University of Minnesota REC, Words+). Additionally, teaching and resource textbooks have been developed focused on the area of functional assessment specific to rehabilitation (Bolton & Cook, 1980; Halpern & Fuhrer, 1984; Granger & Gresham, 1984). The excellent rationale behind this recent attention to functional assessment is rooted in the need for making clear, concise, expedient and accurate decisions in the health care service delivery system. It is acknowledged that without the ability to implement assessment instruments with documented reliability and validity, the profession can only rely on intuition, personal experience, and individual clinical judgement for making decisions. As with most of the disciplines in rehabilitation, the field of rehabilitation technology has traditionally assessed its efficacy in a less than organized and consistent manner.

In the early 1970s, the American Occupational Therapy Association acknowledged the significant inconsistency and splintered approach of assessment in occupational therapy. At that time, they began sponsoring research to evaluate the significance of the problem, implement some strategies to assure a better continuity of evaluation between service delivery settings, and institute a more comprehensive approach for evaluating the efficacy of therapeutic intervention. The most recent step in the development of a better comprehensive performance evaluation for occupational therapists has been the formulation of the constructs and content in the Occupational Therapy Comprehensive Functional Assessment (OTCFA). The significance of the OTCFA to rehabilitation technology is that it provides a method for documenting the efficacy of technological intervention.

REHABILITATION TECHNOLOGY AND ASSESSMENT

Technology and assessment inter-relate in two primary ways. First, assessment methodology in rehabilitation is frequently dependent on technology to perform the acquisition of accurate and cost-effective measures. For example, in the measurement of grip strength, more than nine different brands of dynamometers have provided an objective method of measuring grip strength and are being used in rehabilitation clinics. Without the technological contribution of the dynamometer, grip strength would continue to be measured with inaccurate procedures (Smith and Benge, 1985). The second major relationship between technology and assessment deals with the fabrication and implementation of technological devices, systems, and adaptations as therapeutic interventions. As technology is used in service delivery, it is becoming more and more critical that we understand and document the true efficacy of providing the technology.

Much of quantitative assessment emphasis in recent years has been toward the first type of technology and assessment interaction. A review of the research and development progress reports in the 1986 Veterans Administration Rehabilitation R&D Progress Reports highlights work in physiological monitoring devices, physiological surveillance equipment, computer automated systems for functional assessment, etc. These are all examples of the first interaction between technology and assessment.

Research documenting the efficacy of using various technological interventions in the field of rehabilitation is more rare. Part of the history behind this is that technology tends to have a high face validity, and it is easily recognizable for its potential. Therefore, a systematic, quantitative, scientific measure of its effectiveness has not seemed to be necessary. Also, emphasis in the area of rehabilitation technology has been in research and development of new technologies as opposed to assessing the clinical utilization of the potential technological interventions. This phenomenon is certainly not confined to the area of rehabilitation technology; virtually all of the health care related service delivery disciplines can describe the same scenario. This need has prompted statements about functional assessment being a new specialty within the rehabilitation field (Granger & Gresham, 1984).

Historical and recent work in the area of rehabilitation assessment has produced countless numbers of instruments and approaches for assessing the outcomes of rehabilitation interventions. One of the problems assessments have always encountered is their limitations in scope. This results in constraining the application of the instruments to particular situations and prevents using existing instruments as a comprehensive and common measure for assessing, correlating and comparing. Basically, these assessments are limited by their construct and content scope in three ways.

Many assessments are limited by the population for which they were developed. For example, there is a handful of functional assessments developed specifically for use with the population of individuals who have had a stroke (Ottenbacher, 1980). Assessments in fact have a tendency to be categorized by the populations with which they are intended to be used (see Granger & Gresham, 1984).

The second way assessments tend to be limited in scope is by the setting in which they were introduced. Many assessments are developed particular to the type of health care service that is provided within the organization. An example of this limitation is the instruments which focus on long-term care and lean toward a gerontological orientation (Pfeiffer, 1978). Other examples are scales that were made particularly for acute care (Dubowitz, 1981) and a recent example, due to its focus in acute rehabilitation, is the FIMS (Functional Independence Measures) (Granger, Hamilton & Sherwin, 1986). The third way functional assessments are limited in scope is through the functional area they assess. There are many evaluations, for example, that focus specifically on hand function (Mathiowetz et al., 1985, and Jebsen et al., 1969). Other texts, such as the Barthel (1955), Katz et al. (1963), and Klein-Bell (1982) are examples of functional assessments that are limited to basic self-care skills.

These three functional assessment limitations highlight the difficulty in selecting any particular evaluation tool for assessing a technological intervention. For example, if one were interested in assessing the contribution an automatic page turner has on the overall function of an individual, one would be hard-pressed to locate an adequate assessment that would really describe the impact of introducing this piece of technology to an individual's life. The

Occupational Therapy Comprehensive Functional Assessment (OTCFA) was conceptualized specifically to integrate the various aspects of functional assessment and provide a standard, generic and comprehensive method for assessing the overall performance of an individual, including the technological equipment and environmental factors which contribute to performance.

THE OTCFA

The OTCFA is currently in the middle of its development. The past year and a half has focused on developing a sound construct and content for the assessment. Occupational therapists throughout the country, representing all the service delivery areas of occupational therapy, have been intimately involved in providing discussion and feedback to the project team. Consequently, the early phases of the OTCFA development have been very iterative, with discussion of concepts, terminology and general organization, and multiple revision phases of the OTCFA instrument. The belief is that without a solid construct and content foundation for the instrument, application would be extremely limited.

The overall conceptualization is a hierarchical model of functional performance. There are four levels, with a second dimension being the environment (see Figure 1). This model is unique in that it integrates high level activity functions such as basic self-care activities, home-making activities, vocational and avocational with the skills necessary to adequately perform the activities, with the component abilities (which provide the basic elements to achieve the skills necessary to perform the activities). The environment is viewed as a second dimension as opposed to simply categories within the performance areas, because all social, cultural and physical environmental factors do not stand alone, but directly affect performance on the higher level activities, the next level integrated skills, and the lowest level component abilities.

As of June 1987, the full scale OTCFA includes five levels, fourteen major areas, and 117 detailed categories of function. Specific examples on the activity level include dressing, eating, reading, writing, community mobility, and household repair. Examples of the categories on the skill level include fine coordination, gross coordination, and specific problem solving skills, such as identifying that there is a problem. Examples on the component level include muscle strength, passive range of motion, pain, visual acuity, and tactile sensation. Examples of the categories of the environment include financial resources, medical resources, transportation resources, orthotics, and adaptive equipment.

While the implications of the OTCFA in the area of rehabilitation technology are many, two are key here. First, the OTCFA is able to point out the exact contribution that a technological device is making to a person's overall performance. Some types of devices, for example, certain types of hand and wrist splints, do nothing to contribute directly to performance in activity but may stabilize a joint or joints which permits a higher level set of skills in hand function, and contribute to an increased performance of many activities. On the other hand, a particular adaptive device such as a rocker knife permits an individual to use one hand for primarily one activity, that being eating. This low technological device does not generalize to other areas of performance. It becomes an activity-devoted device.

A second implication of the OTCFA in regard to rehabilitation technology assessment is its sensitivity. Sensitivity in functional assessments can be obtained in two methods. One is to take any category of function and break it down into a finely graded scale. For example, a team functional assessment in California breaks down every category of impairment into 100 points. This successfully increases the sensitivity of the scale, and can document very small changes in the particular functional domain. Another method of increasing sensitivity, which more easily retains high reliability, is to increase the number of categories that are being considered. The Klein-Bell ADL scale (Klein & Bell, 1982)) is an example of this method to increase sensitivity. Their scale focuses on basic self-care skills, and documents 170 categories of behavioral function. The OTCFA uses the second method to maintain its sensitivity to change, by incorporating its 117 categories.

The OTCFA provides a set of graphs which consolidate the performance data into summary information. These graphs can depict the integration and the sensitivity of the OTCFA in the application to technological intervention.

Figure 2 illustrates the OTCFA graph displaying the functional impact of an automatic page turner into a person's environment. As can be seen, the influence of a page turner is primarily with the second level, which focuses on activities. Additionally, since the need for a page turner falls within the environmental dimension, the environmental area reflects that there is a need in this area. Another example is illustrated in Figure 3. This describes the functional status of someone who does not have any motor function of the upper limbs, and thus has no direct physical mechanism for manipulating the environment. Here, the individual's status before the introduction of a technological device, and then subsequent function of the individual with a mouthwand system in use. (Both of these illustrations have specifically isolated only the deficits relevant to the page turner or the mouthwand system in order to point out the sensitivity and dispersement of function within the OTCFA. In reality, individuals would virtually never exhibit such a simplistic functional picture, but this demonstrates the specific impact of a technological need.)

OVERALL IMPLICATIONS OF THE OTCFA ON TECHNOLOGY

Rehabilitation technology, as with all of the other rehabilitation disciplines, is being pressed into collecting data demonstrating the efficacy of its interventions. The OTCFA provides one method for approaching the measurement of overall effectiveness of any technology. The OTCFA performs this measurement function using a comprehensive, hierarchical designed assessment for specifically isolating the contributions any intervention has for an individual. The OTCFA to date is within the piloting stage. The past year and a half has focused on formulating appropriate construct and content validity concepts. If a careful up-front process is used, the instrument will be much more effective and statistical validity and reliability studies will be confirmed. It is anticipated that the nation-wide pilot studies, subsequent revision of the instrument, development of instructional materials, including a teaching videotape, identification of test-retest reliability and inter-rater reliability will be completed by mid-1988.

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REFERENCES

Bolton, B. & Cook, D.W. (1980). *Rehabilitation client assessment.* Baltimore: University Park Press.

Dubowitz, L. & Dubowitz, V. (1981). The neurological assessment of the pre-term and full-term newborn infant. Clinics in Developmental Medicine, No. 79. London: William Heinemann Medical Books.

Granger, C.V. & Gresham, G.E. (1984). *Functional assessment in rehabilitation medicine.* Baltimore: Williams and Wilkins.

Granger, C.V., Hamilton, B.B., & Sherwin, F.S. (1986). *Guide for the use of the uniform data set for medical rehabilitation.* Buffalo, NY: Task Force for Development of a Uniform Data System for Medical Rehabilitation, Department of Rehabilitation Medicine, Buffalo General Hospital.

Halpern, A.S. & Fuhrer, M.J. (1984). *Functional assessment in rehabilitation*. Baltimore: Paul H. Brookes Publishing Company.

Iverson, I.A., Silberberg, N.E., Stever, R.C., & Schoening, H.A. (1973). *The Revised Kenny Self-Care Evaluation*. Minneapolis: Sister Kenny Institute.

Jebsen, R.H., Taylor, N., Trieschmann, R.B., & Trotter, N.J. (1969). An objective and standardized test of hand function. Archives of Physical Medicine and Rehabilitation, 50, 311-319.

Katz, S., Ford, A.B., Moskowitz, R.W., Jackson, B.A., & Jaffe, M.W. (1963). Studies of illness in the aged: The index of ADL: A standardized measure of biological and psychosocial function. Journal of the American Medical Association, 185, 914-919.

Klein, R.M. & Bell, B. (1982). Self-care skills: Behavioral measurement with Klein-Bell ADL Scale. Archives of Physical Medicine and Rehabilitation, 63, 335-338.

Mahoney, F.I. & Barthel, D.W. (1965). Functional evaluation: The Barthel Index. Maryland State Medical Journal, 14, 61-64.

Mathiowetz, V., Volland, G., Kashman, N., & Weber, K. (1985). Adults norms for the box and block test of manual dexterity. American Journal of Occupational Therapy, 6, 386-391.

Ottenbacher, K. (1980). Cerebrovascular accident: Some characteristics of occupational therapy evaluation forms. American Journal of Occupational Therapy, 34, 268-271.

Pfeiffer, E. (Ed.) (1978). *Multidimensional functional assessment: The OARS methodology*. Durham, NC: The Center for the Study of Aging and Human Development, Duke University Medical Center.

Smith, R.O. & Benge, M.W. (1985). Pinch and grasp strength: standardization of terminology and protocol. American Journal of Occupational Therapy, 8, 531-535.

Veterans Administration. (1986). Rehabilitation R&D Progress Reports: 1986. Washington, DC: Office of Technology Transfer (153D), Veterans Administration Medical Center.

RELATIONSHIP OF FUNCTIONAL ASSESSMENT AREAS

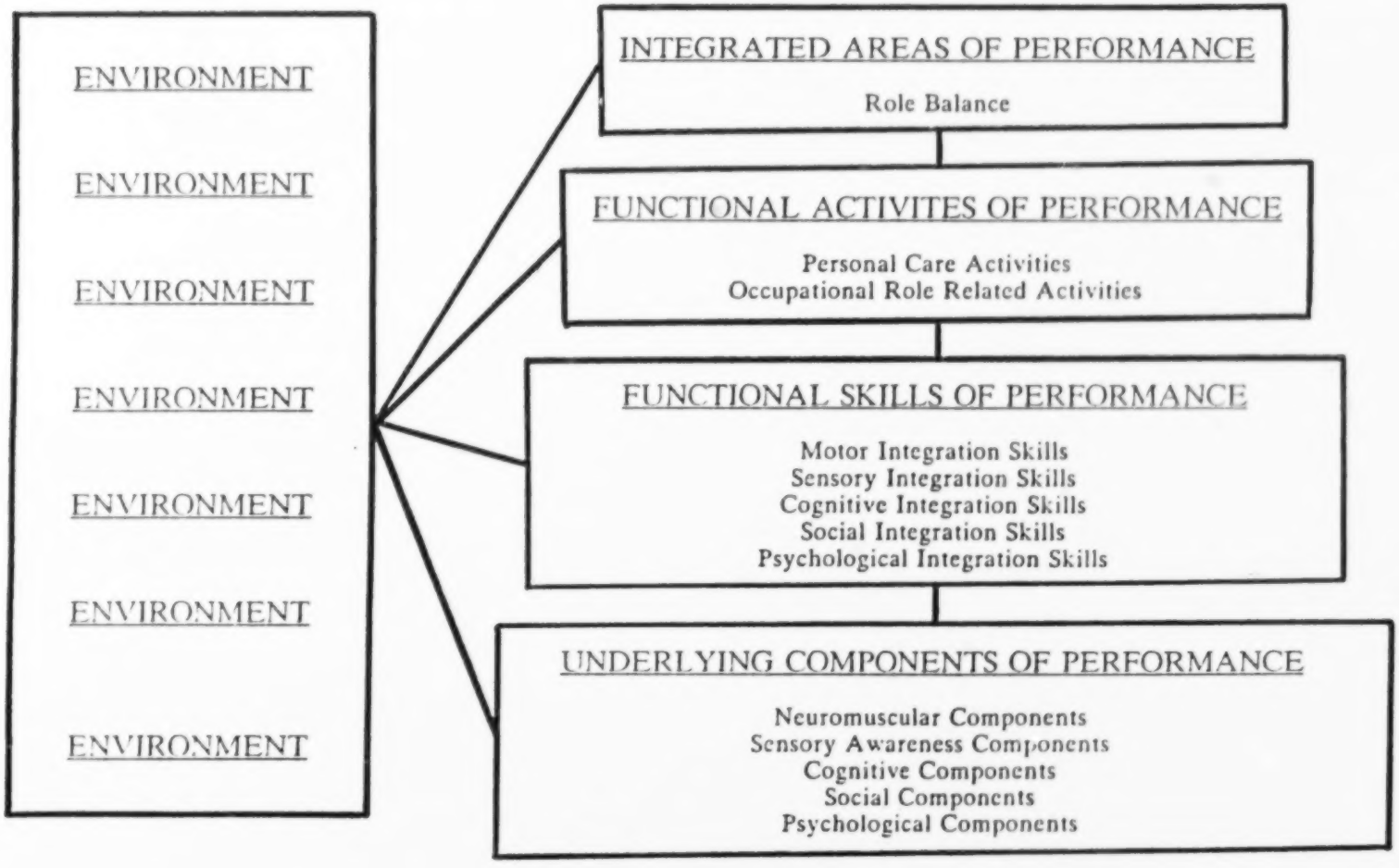
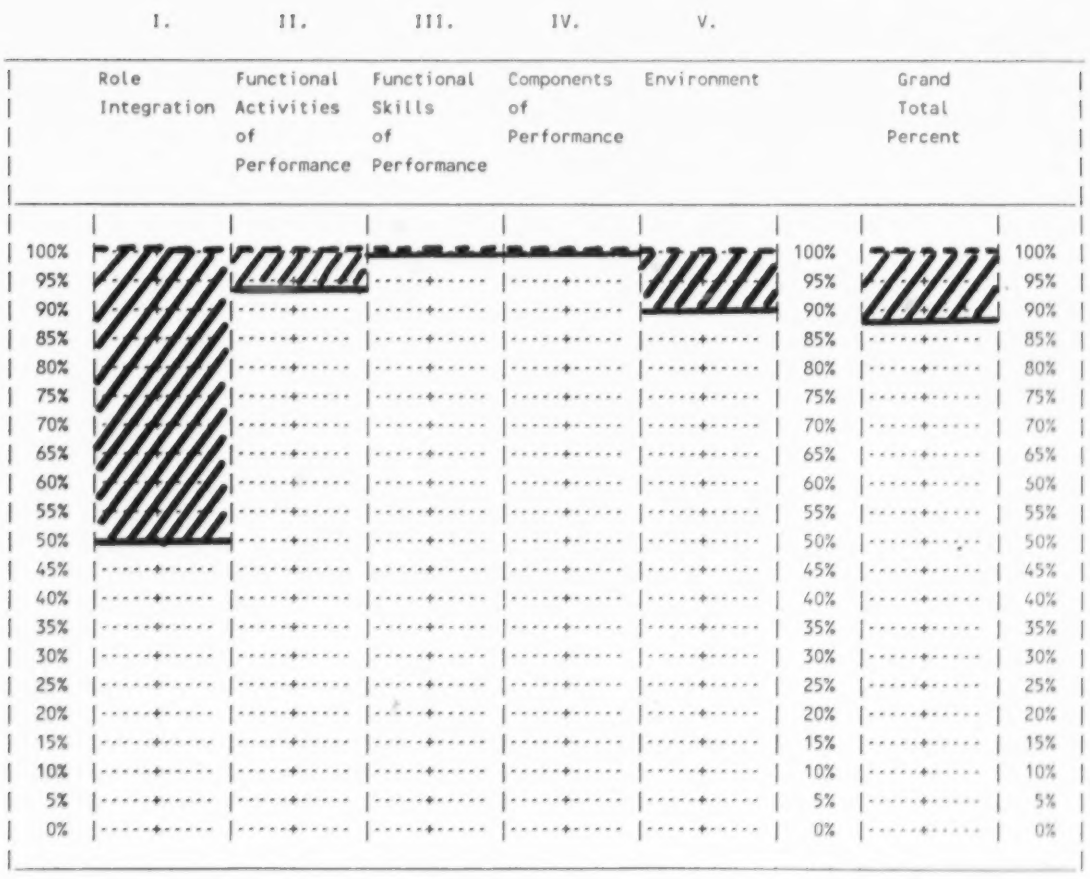


FIGURE 1

DRAFT

FIGURE 2

OTCFA Long Form
GRAPH #1 (SUMMARY)
PERCENT OF NEEDED PERFORMANCE

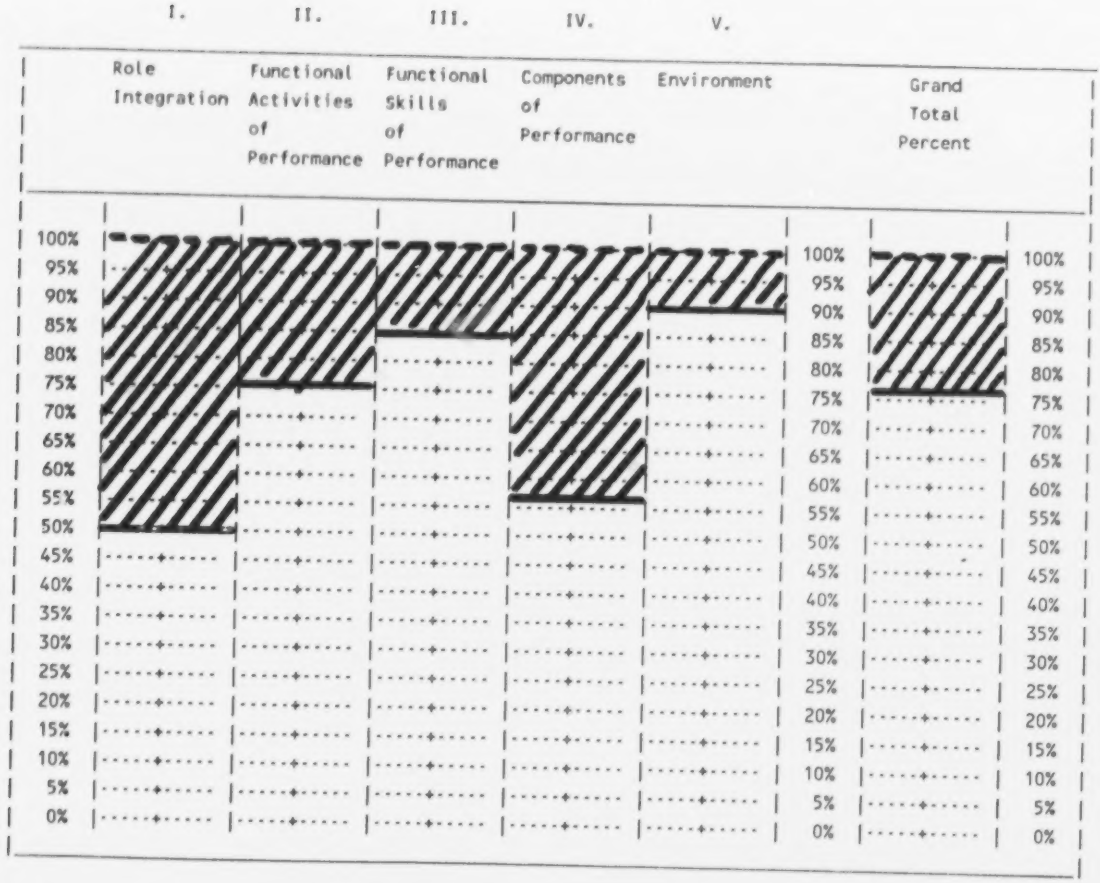


Date _____ Total Percent 50 (from p.1) 80 (from p.37) 100 (from p.48) 100 (from p.58) 90 (from p.61) Grand Total 88 (from p.61) ——— without page turner

Date _____ Total Percent 100 (from p.1) 100 (from p.37) 100 (from p.48) 100 (from p.58) 100 (from p.61) Grand Total 100 (from p.61) ●●●●● with page turner

FIGURE 3

OTCFA Long Form
GRAPH #1 (SUMMARY)
PERCENT OF NEEDED PERFORMANCE



Date _____ Total Percent

50	76	85	57	90	Grand Total 77	——— without mouthwand
from p.1	from p.37	from p.48	from p.58	from p.61	from p.61	

Date _____ Total Percent

100	100	100	100	100	Grand Total 100	---- with mouthwand
from p.1	from p.37	from p.48	from p.58	from p.61	from p.61	

FEATURES TO INCREASE THE ACCESSIBILITY OF COMPUTERS BY PERSONS WITH DISABILITIES: REPORT FROM THE INDUSTRY/GOVERNMENT TASK FORCE

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ABSTRACT

In 1984, representatives of the major computer companies met with researchers, consumers, and government personnel to discuss the issue of computer access by disabled persons, and the role that standard computer manufacturers might play in enhancing access for disabled persons. This led to the formation, two years later, of the Industry/Government Task Force on Design of Computers to Increase Their Accessibility by Disabled Persons. This is a voluntary, advisory group whose objective it is to identify the primary difficulties faced by disabled persons in the use of standard manufactured computers as well as possible approaches for reducing the difficulties. The Task Force also helps to identify those current features of standard microcomputers which facilitate their use by disabled persons, so that the features might be enhanced and not lost. The two products of the Task Force to date have been a list of features/capabilities (presented here), and a more extensive document titled "Considerations in the Design of Computers and Information Processing Systems to Increase Their Access by Persons with Disabilities."

The majority of the items identified were found to have direct implications for increasing the usability of the computer systems by nondisabled persons as well. Most aspects targeted for disabled persons could be implemented in future computer systems on a low-cost or no-cost basis.

MECHANISMS FOR MAKING COMPUTERS MORE ACCESSIBLE

Features which would make computers more accessible can basically be broken down into two groups:

a) features which allow persons with disabilities to access and use computer that are not owned by or assigned to them (public or shared computers);

   Type 1) features that allow individuals with mild impairments to use the computers directly as they come from the box;

   Type 2) features that facilitate the connection of specialized interfaces and accessories for individuals with more severe disabilities.

b) features which facilitate the use of computers which are personally owned or controlled by the disabled individual;

   Type 3) features that facilitate customization of a personal computer to allow access to standard software;

   Type 4) features that make computer use easier but are not required for access;

   Type 5) features that facilitate special applications for computers.

For companies interested in enhancing access to general use computers, it is the first group (types 1 and 2) that is of the highest priority. These features allow people with disabilities to use computers as they come across them - rather than having to disassemble or modify the computer or its software in order to gain access.

Figure 1 provides a listing of some (not all) features from each of these categories. Many of these modifications can be implemented in software, often as relatively minor modifications or extensions to the operating system of the computer. As such, they do not increase the manufacturing cost of the computer. Even hardware design modifications, which would be very expensive on a retrofit basis, can usually be implemented without increase in manufacturing cost on future systems. In Figure 1, those items which could be implemented through software modifications are marked with an asterisk. Note that most of the modifications would increase the flexibility or ease of use of the computers for the non-disabled "mass market" as well.

THE MULTIPLIER EFFECT - ARE ACCESSIBLE DESIGNS THE MASS MARKET DESIGN?

While many of the design features implemented for individuals with disabilities will also benefit the mass population, there are some features which can be implemented which are really only of direct benefit to those individuals with more limited abilities. Implementing these features may not seem to be as economically sound as those features which also benefit the mass market. After all, in general, products are designed to address the bulk of the market, and only take small market segments into account if they can be implemented on a no-cost or low-cost basis. Individuals who have disabilities, even though they represent 20% of the population, are still a minority of the population. When it is further realized that 20% represents all of the disabilities, and any particular disability is only a portion of that number, the justification for specialized adaptations or accommodations is reduced further.

There are, however, several multiplying factors which make the impact of this market segment greater than it first appears. Most of these factors deal with the fact that marketing of computers is generally not targeted at individuals, but at groups of individuals (e.g., a company, a school, etc.). In general, people buying computers for that group or organization would like to buy computers which can be used by everyone in that group/organization. If everyone in that group/organization cannot use the computer, and the computer becomes an integral part of that group's or organization's activities, then there will be some of the members of that group who will be unable to function in the group. In a school, this would translate into children who were unable to participate in the regular classrooms that used computers. In a company or agency, this would translate into individuals who were unable to be hired into or retain jobs which required access to and use of the computers being purchased.

The result is that, although only 20% of the population is disabled, the percentage of companies, agencies, schools, etc. which would like to allow disabled persons to work in the same environments and on the same computers as their able-bodied peers is closer to 80%. If computers are being

FIGURE 1:
FEATURES WHICH ALLOW/FACILITATE USE OF COMPUTERS BY PERSONS WITH RESTRICTED ABILITIES

TYPE 1: FEATURES THAT ALLOW MORE PEOPLE TO USE THE COMPUTER AS IT COMES FROM THE BOX:
- Allows access to standard software without requiring modifications.
- Needed for access to public/shared computers (school, company, community) (also Type 2, for more severely impaired persons).

PHYSICAL IMP:
- * Keyboard operable with 1 hand (1 finger or mouthstick, etc.) (invokable feature).
- * Mouse cursor completely controllable from the keyboard (*if* system has mouse).
- * Touchscreen/touchpad completely controllable from the keyboard (*if* system has touchscreen/touchpad).
- ● Separate keyboard (movable/positionable).
- * Key repeat defeatable.
- ● Disks easy to insert and remove (e.g., with arthritic hands, or using tongs held in mouth).
- ● External disk drive that can be used to boot (allows special positioning of drive).
- ● Slide, thumbwheel, pushbutton (or keyboard operable) controls (*if* required for system operation).
- ● On/off from front of computer.

VISUAL IMP:
- * Zoom or screen image enlargement feature (full screen access required).
- ● Large high contrast letters on keyboard.
- ● Nibs on home and important peripheral keys (ESC, Backspace, DELete).
- ● Standard location of keys
- * Colors user specifiable (including black on white versus white on black), or color information redundant.
- ● Separate monitor (repositionable).

BLINDNESS: – Nothing for BLINDNESS in TYPE 1 FEATURES: see TYPE 2 FEATURES.

HEARING IMP: ● Volume controllable (plus reasonably high volume level possible).

DEAFNESS: * Visual display of any beeps, sounds, or speech output.

COGNITIVE IMP:
- * Consistent, simple format and language, non-memory based.
- * Reversible actions.
- * On-line Help.

TYPE 2: FEATURES THAT ALLOW CONNECTION OF SPECIAL INPUT/DISPLAY DEVICES TO COMPUTERS:
- Needed for access to public/shared by persons with moderate to severe sensory/physical impairments.
- Allows access to standard software.

PHYSICAL IMP: * Standard alternate input connection point (external) (input treated identically to standard input devices). (allows connection of wide variety of alternate inputs – eyegaze, headpointing, morse, voice, etc.)

BLIND/VISUAL IMP: * External connection point where screen display contents are available. (allows connection of different alternate display devices – Braille, tactile, voice, etc.)

HEARING IMP: ● Headphone/audio connection point.

TYPE 3: FEATURES THAT FACILITATE CUSTOMIZATION OF PERSONALLY OWNED COMPUTER TO ALLOW ACCESS TO STANDARD SOFTWARE (Types 1 and 2 above would also apply here)

PHYSICAL IMP:
- * Injection point in system where a background program can inject keystrokes and mouse/touchpad actions.
- * Phantom window which stays above active windows (invokable – lasting).
- * Standard system drivers/structure for all types of input (facilitates design of compatible alternatives).
- ● Switch input point (jack or dedicated pins on other connector).
- ● Provision for keyguard mounting (e.g., groove on sides of keyboard, etc.).

BLIND/VISUAL IMP:
- ● Connection point for larger displays (e.g., video connector).
- * Built-in voice capability (facilitates voice output of screen information).

ALL
- ● Open architecture (plenty of slots).
- ● Manuals in electronic form (ease of handling; allows alternate display forms).

TYPE 4: FEATURES THAT MAKE COMPUTER USE EASIER BUT ARE NOT REQUIRED FOR ACCESS

PHYSICAL IMP:
- * Key repeat/delay user adjustable.
- ● On portable computers, latches operable with one (very arthritic) hand or mouthstick, etc.
- ● On portable computers, space inside case for permanently mounted keyguard.

BLIND/VISUAL IMP: ● Manuals in Braille or voice (or electronic).

TYPE 5: FEATURES THAT FACILITATE DESIGN OF SPECIAL APPLICATIONS FOR COMPUTERS (BUT NOT REQUIRED FOR ACCESS TO STANDARD APPLICATIONS SOFTWARE)

- * Built-in voice capability (blind, speech impaired, deaf-phone).
- ● Ability to route computer sound (speech) through modem (speech impaired, deaf).
- ● On portable computers, pretapped holes on bottom (to attach special accessories).
- ● Portables flat when closed.

* indicates feature could be implemented in system software

designed for these "group" markets rather than just selected individuals within these groups, then "groups which include individuals with some type and degree of disability" becomes the "mass market" or target market.

As computers have moved from optional productivity tools to required tools on the job or in the classroom, this has become increasingly clear. School systems have let out requests for bids for computer purchases stating that accessibility for their disabled students was required in order to qualify. The U.S. Congress, as part of the new Rehabilitation Act, has also acted to help ensure that computers and office automation equipment purchased by the government would meet minimum accessibility standards. Section 508(a) of the revisions to the Rehabilitation Act state:

"Sec. 508(a)(1) The Secretary, through the National Institute on Disability and Rehabilitation Research and The Administrator of the General Services, in consultation with the electronics industry, shall develop and establish guidelines for electronic office equipment with or without special peripherals.

"(2) The guidelines established pursuant to paragraph (1) shall be applicable with respect to electronic equipment, whether purchases or leased.

"(3) The initial guidelines shall be established not later than October 1, 1987, and shall be periodically revised as technologies advance or change.

"(b) Beginning after September 30, 1988, the Administrator of General Services shall adopt guidelines for electronic accessibility established under subsection (a) for Federal procurement of electronic equipment. Each agency shall comply with the guidelines adopted under this subsection.

"(c) For the purpose of this section, the term special peripherals means a special needs aid that provides access to electronic equipment that is otherwise inaccessible to a handicapped individual."

This action was taken in response to a concern that the increasing use of computers and office automation equipment in the government could significantly impact on disabled government employees. It was felt that, as computers became mandatory parts of the job, inaccessible computers could cause individuals with disabilities to lose their positions, be unable to be hired into positions, or block their promotion or transfer into positions requiring computer use. Even the Department of Defense has particular interest, due to a concern for disabled veterans.

Although the NIDRR/GSA Guidelines have not yet been drawn up, they are expected to be general performance guidelines in nature. The objective is to provide industry with a clear indication of what would be required to provide "reasonable accessibility," while leaving the actual method for achieving this up to industry. This type of flexibility would be essential to prevent hindering innovation and advancement in this important area.

CONCLUSION

There are may ways in which current and future computers could be designed to make them more usable by persons with disabilities. Most of these are no-cost or low-cost in nature, and benefit nondisabled users as well.

Two efforts ongoing at the present time in this area are:

1) Industry/Government Initiative on Computer Accessibility: A voluntary effort targeted at generating better information for industry and facilitating cooperative efforts in this area. (Anyone may join this effort by writing to Dr. Gregg C. Vanderheiden or Dr. Lawrence Scadden – see below.)

2) NIDRR/GSA Effort to develop procurement guidelines for government purchase of electronic office automation equipment including computers.

NOTE: The list of features in Figure 1 is not meant to be exhaustive, nor should it be seen as a checklist for accessibility. It is merely presented as a listing of examples of the types of features which might be provided for current generation computers to increase their accessibility.

Anyone wishing more information on this topic area, or wishing to join in the Industry/Government Initiative (which is open to all) should contact:

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